THE NIAGARA FALLS POWER COMPANY

NIAGARA FALLS, N. Y.

CANADIAN NIAGARA POWER COMPANY

NIAGARA FALLS, ONTARIO.

APRIL 1, 1913

INFORMATION FOR VISITORS

THE requests for permission to inspect the plants of The Niagara Falls Power Company, and of its allied company, the Canadian Niagara Power Company, are so numerous that it is impossible for the officers of either Company to give individual attention to such requests. The Companies desire, however, to afford visitors every reasonable facility for the gratification of the interest that is taken in their power developments, and to this end have provided competent guides for the purpose of conducting visitors through the different establishments.

To defray the cost of this service, a small admission fee is charged. From the admission receipts, after paying expenses, a bed in the Niagara Falls Memorial Hospital has been endowed for the use of employees who may be disabled by sickness or accident. From these receipts, appropriations are made also for the purposes of the local hospitals, of the Employees' Beneficial Association, and for the benefit of the employees in other ways.

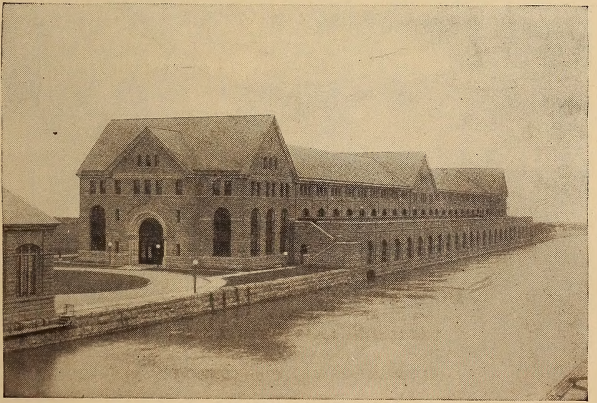
The ticket of admission to either the Canadian or the American plant entitles the holder, subject to the rules of the Company and to restrictions that may be imposed from time to time by the Superintendent of Operation, to visit the plant accompanied by a guide.

The admission of visitors may be suspended temporarily at any time by the Superintendent at his discretion.

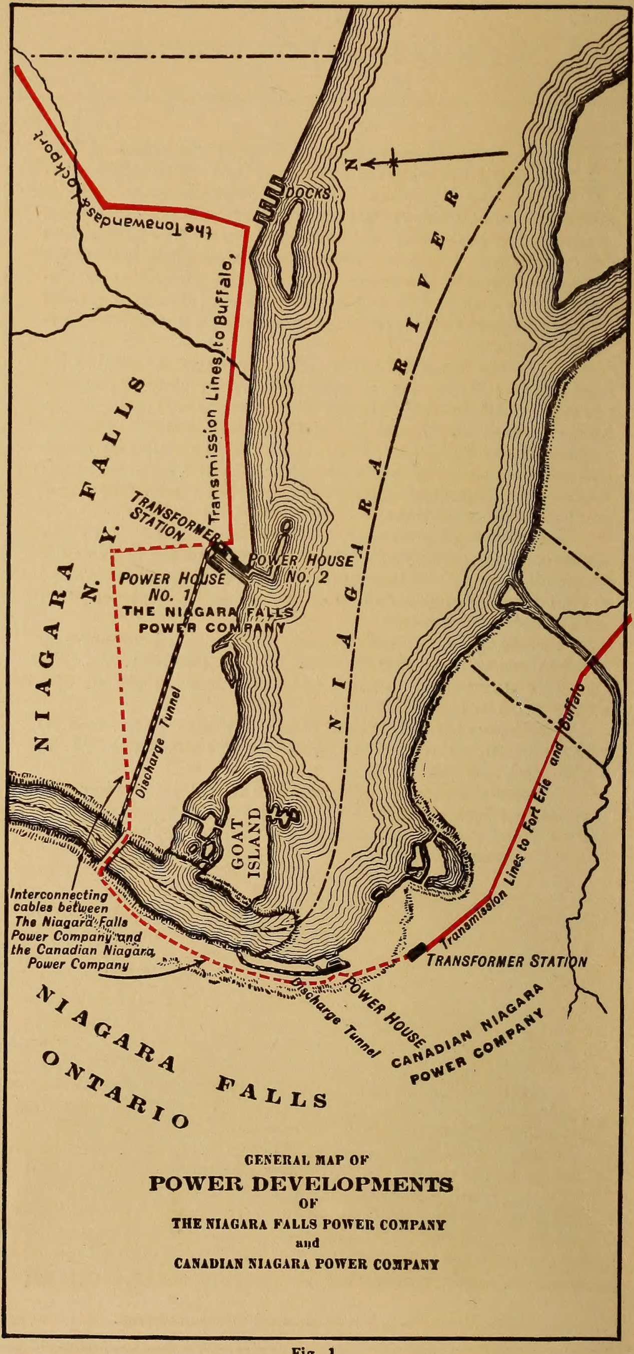
The number of persons in each party in charge of a single guide is limited to ten.

The hours for visitors are from 9 o'clock A. M. to 5:30 o'clock P. M. on week days, and from 10 o'clock A. M. to 4 o'clock P. M. on Sundays.

Visitors are earnestly requested to report in writing any incivility or lack of attention on the part of the guides or any other cause for complaint that may arise on the premises of either Company.



Power House No. 2, The Niagara Falls Power Company.



GENERAL MAP OF
POWER DEVELOPMENTS
OF
THE NIAGARA FALLS POWER COMPANY
and
CANADIAN NIAGARA POWER COMPANY

Fig. 1

HARNESSING NIAGARA FALLS

IN less than eight tmiles of its length, the level of the Niagara River falls about 314 feet. Of this amount, the sheer drop at the American Falls proper is only 168 feet, and of the balance, 50 feet represents the change in the level of the river in the rapids above the Falls, and 96 feet that in the gorge below. The average flow of water in the river is approximately 210,000 cubic feet per second, and the momentum or kinetic energy of such a volume of water falling through a total distance of 314 feet is theoretically capable of developing about 7,500,000 h. p. The value, therefore, of the Niagara River as a possible source of power has always been recognized by engineers, but it was not until the very end of the last century that the utilization of this power in large quantities became an accomplished fact.

That Niagara Falls represented a natural source of tremendous power was known, but the mere recognition of a possible source of power is not the real problem in its commercial development. Two other factors require even greater consideration—first, some means must be provided for converting the forces of nature into some useful and marketable form of energy, and second, when it is converted into a useful form of energy, a sufficient demand for the power must be created to justify its development upon a large and practical scale. The discovery of efficient and economical methods of generating and transmitting electrical energy became the means by which the power of Niagara Falls could be developed successfully in a commercial form, and following quickly thereafter, the phenomenal growth of the electrochemical industries has supplied to a large extent the requisite demand for the power developed. Nevertheless, it is in no small measure due to the energy, courage and perseverance of the directors of The Niagara Falls Power Company and their associate engineers that Niagara Falls owns its present importance as an industrial centre.

Upon October 4, 1890, ground was broken at Niagara Falls, N. Y., for the initial power installation of The Niagara Falls Power Company. The trial development was for 15,000 h. p. At that time, three small towns with a combined population of less than 10,000 were contained within the limits of what is now the City of Niagara Falls. The assessed valuation of all three towns was about $7,000,000.00. Five years later, the first electrical power from the initial installation was delivered commercially to The Pittsburg Reduction Company for the manufacture of aluminum. Today, twenty-three years after the breaking of ground for the tunnel, the aggregate amount of power developed by The Niagara Falls Power Company and its allied interest, the Canadian Niagara Power Company, is about 175,000 h. p., with additional capacity in course of construction amounting to 50, 000 h. p. Niagara Falls is now a city of over 35,000 inhabitants with an assessed valuation amounting to over $32,000, 000.00. Such in brief are some of the results accomplished by the harnessing of Niagara Falls. Less than seven per cent. of the total flow of water over Niagara Falls has been diverted by these companies and its beauty and grandeur are unimpaired.

DESCRIPTION OF PLANTS

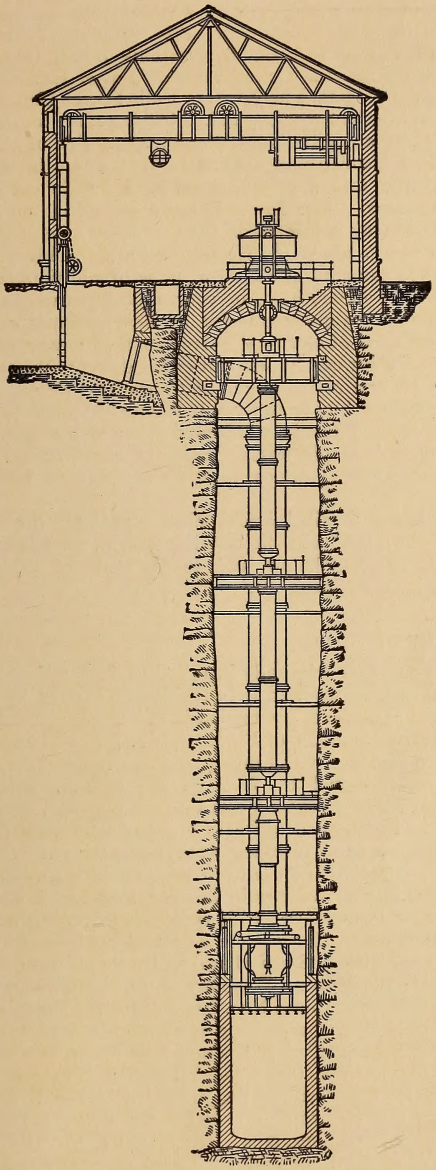
THE essential hydraulic features of any water power development are an upper level from which the necessary volume of water can be diverted, pipes or penstocks through which the diverted water flows, a lower level into which it can be discharged and suitable means of converting the potential energy of the water into a form in which it can be readily controlled and utilized. This last may be done by means of turbines or water wheels placed at the lower ends of the penstocks.

In all three plants of The Niagara Falls Power Company and the Canadian Niagara Power Company, the same general design of power development has been followed. The water is drawn in from the level of the upper river through an intake canal, and is thence distributed to the inlet chambers at the head of each penstock. These chambers are protected along the front by iron racks or gratings, which remove all floating ice, logs and other debris. In two of the Power Houses, additional protection is obtained by an apron wall outside of the iron racks, the water passing from the intake canal into a covered rack chamber through arched openings located below the surface of the water.

A lower level for the discharge of the water taken in at the penstock inlets is obtained by sinking into the earth through solid rock, for a depth of approximately 180 feet, a long, narrow shaft, or wheelpit, over which the Power House itself is located. Down this wheelpit pass a series of parallel vertical penstocks, carrying to the turbines below the water diverted from the river above. From the turbines, the water is discharged into the bottom of the wheelpit, and thence finds an outlet to the lower level of the river in the gorge below the Falls through a long tunnel with a horseshoe-shaped cross section cut through solid rock at an average depth of 200 feet below the surface. A cross section of the wheelpit of Power House No. 1 is shown in Fig. No. 2.

The mechanical power developed in each turbine is transmitted to the electrical generators located on the Power House floor by means of revolving vertical steel shafts passing up through the wheelpit, there being one generator for each turbine. A governor located at the side of each generator operates valves in the turbine in the wheelpit below, and automatically controls the amount of water flowing through the turbine with any change in the amount of electrical power drawn from its generator. In the two Power Houses on the American side, the capacity of the turbines and generators is 5,500 h. p. each; in the Canadian Plant, 5 units of 10,000 h. p. and 2 units of 12,500 h. p. are installed.

From the generators, the power, now in the form of electrical energy, is distributed through copper cables to the main copper bus bars located in a subway below the Power House floor, and from these bus bars is sent out over feeder cables run in ducts under ground to the different manufacturing establishments located nearby, or is sent to the step-up transformer stations for transmission at higher voltage to Buffalo, Lockport, the Tonawandas, Olcott, Bridgeburg and Fort Erie. The whole system of generators and feeders is con-



Cross Section of Wheelpit, Power House No. 1

Fig. 2

trolled and regulated in each Power House from a main switchboard gallery in charge of one man.

An idea of the system as a whole may be gained by reference to Fig. 1, showing the relative positions of the three Power Houses, the various power transmission lines and the interconnecting cables. Power Houses Nos. 1 and 2, belonging to The Niagara Falls Power Company and having an installed capacity of 115,000 h.p., are located about one mile above the Falls on the American side of the river. These two installations operate from a single intake canal and discharge into a single tunnel having sufficient capacity for both plants. The Power House of the Canadian Niagara Power Company is located on the Canadian side of the river, a short distance above the Horseshoe Fall. This plant has an installed capacity of 75,000 h. p. with additional capacity amounting to 50,000 h. p. in course of construction. All three plants are interconnected by heavy copper cables for the transmission of electrical energy so that power generated in any one plant can be sent out either direct to the customers supplied by that plant, or can be transmitted through the interconnecting cables to either of the other two plants for similar distribution. Thus the whole system is a single unit of great flexibility with ample reserve capacity assuring continuous and uninterrupted service to the customers of both companies.

For more detailed information regarding the different parts of the plant and distributing system, reference is made to the paragraphs below and to the table of comparative figures given on page 10.

TURBINES:

The turbines originally installed in Power House No. 1 were Fourneyron inverted twin turbines designed by Faesch & Piccard of Geneva, Switzerland, and manufactured by the I. P. Morris Company of Philadelphia, Pa. These turbines have been replaced with Francis single turbines of the inward-flow type, designed by Mr. C. C. Egbert, Mechanical Engineer of The Niagara Falls Power Company, and manufactured by the Bethlehem Steel Company of South Bethlehem, Pa. The original turbines were not provided with draft tubes. Those now in use are equipped with single, central draft tubes. The turbines in Power House No. 2 are of the inward-flow Francis type with single runners, but with double draft tubes. They were designed by Escher Wyss & Company of Zurich, Switzerland, and were built and installed by the I. P. Morris Company of Philadelphia. At the Canadian Plant turbines Nos. 1 to 5 are of the Francis double runner inward discharge type with double draft tubes, designed by Escher Wyss & Company by whom turbines Nos. 1 to 3 were manufactured and installed. Turbines Nos. 4 and 5 were manufactured and installed by the I. P. Morris Company. Turbines Nos. 6 and 7 are of the Francis double inward discharge type, designed by Mr. Egbert and manufactured by the Bethlehem Steel Company. They are equipped with a third draft tube, centrally located, to take the discharge from the lower runner. For further details, see comparative table on page 10.

GOVERNORS:

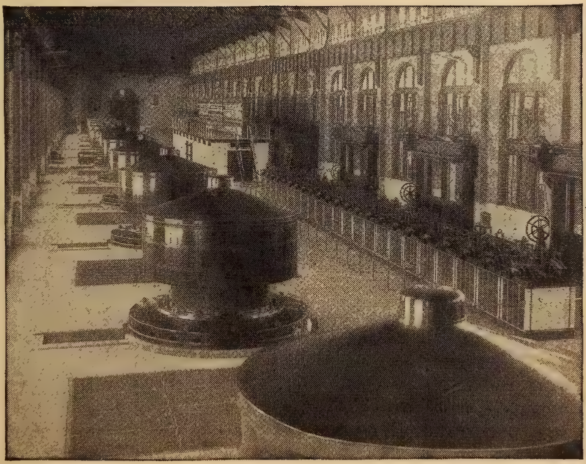
The flow of water at the turbine wheels is controlled automatically by governors which maintain a constant speed at the electric generators no matter what change occurs in the load. Earlier types of governors installed in the American Power House No. 1 have been superseded by oil pressure governors which are now in use throughout the three power houses of the American and the Canadian Companies. These governors were designed by Escher Wyss & Company by whom the governors in American Power House No. 1 and in the Canadian Power House were manufactured. The governors in Power House No. 2 were manufactured by Falkenau-Sinclair Machine Company, of Philadelphia, Pa.

GENERATORS:

The ten generators in Power House No. 1 are of the external revolving field type and were designed and manufactured by the Westinghouse Electric & Manufacturing Company of Pittsburgh, Pa. The eleven generators in Power House No. 2 were designed and manufactured by the General Electric Company of Schenectady, N. Y. The first six generators in Power House No. 2 are similar in design to those in Power House No. 1. The other five have internal revolving fields. Of the seven generators in the Canadian plant five were designed and built by the General Electric Company of Schenectady, N. Y., and two by the Canadian Westinghouse Company of Hamilton, Ontario. All have internal revolving fields. For further details, see comparative table on page 10.

THRUST BEARINGS:

The aggregate weight of the revolving parts of each turbine and electric generator, together with the sections of hollow and solid shafting connecting the two, amounts to



Interior of Power House No. 2, The Niagara Falls Power Company

COMPARATIVE TABLE

All Dimensions are given in feet

	American Plant		Canadian Plant
	No. 1	No. 2	
Intake Canal			
Length	1200		271
Width	119-194		282-526
Average depth water	12		14.4
Tunnel			
Length	7481		2165
Height	21		25
Maximum width	18.8		18.8
Wheelpit			
Length	424.47	461	564.3
Width	17.5	17.5	18
Average depth	177,7	177.4	160.6
Penstocks			
Number installed	10	11	7
Diameter	7.5	7.5	10.2
Turbines			
Number installed	10	11	7
Capacity in horse-power each	5500	5500	{ 5-10000 2-12500
Average effective head	140	140	140
Draft tubes	1	2	{ 5-2 2-3
Depth below power house floor	134.5	133.0	122.8
Outside diam. turbine runner	5.33	5.33	5.33
Single or double runner	Single	Single	Double
Discharge	Inward	Inward	Inward
Generators			
Number installed	10	11	7
Capacity in horse-powei each	5500	5500	{ 5-10000 2-12500
Revolutions per minute	250	250	250
Voltage	2200	2200	12000
Phase	Two	Two	Three
Cycles	25	25	25
Number of field poles	12	12	12
Exciters			
Number installed	4	4	6
Capacity in horse-power each	168	200	267
Voltage	220	220	125
Revolutions per minute	550	750	600

from 150,000 to 268,000 pounds. In American Power House No. 1 this entire weight is supported by a combination oil pressure and roller thrust bearing. In Power House No. 2 and in the Canadian plant the revolving mass is for the most part counterbalanced by the hydrostatic upward pressure of water in a compartment of the turbine wheelcase acting upon the lower surface of a disc secured to the shaft. In addition to this balance piston an oil pressure thrust bearing is placed in each vertical shaft just below the power house floor. This thrust bearing consists of two discs, the lower one stationary and the upper one attached to the revolving shaft. Between these two discs, oil is forced under heavy pressure, the weight of the shaft and revolving parts being carried by the film of oil between the two discs.

SWITCHBOARDS:

Two main switchboards are installed in Power House No. 1, each controlling and distributing the output of five generators. The main generator and feeder switches are operated pneumatically, and were designed and built by the Westinghouse Electric and Manufacturing Company. In the case of Power House No. 2 and of the Canadian Power House, the entire output of each plant is controlled and distributed from a single operating switchboard through groups of electro-magnetically operated oil-break generator and feeder switches. The switchboard appliances in these two plants were designed by the General Electric Company under specifications of the Power Company's engineers.

Fig. 3

LOCAL DISTRIBUTING PLANTS:

A map of the Power Company's lands adjoining the Power House on the American side of the river is shown in Fig. 4, page 13. Here are located some thirty industries utilizing over 100,000 h. p. for manufacturing purposes. Except in the case of the more distant plants, the power for these industries is distributed at generator voltage, namely, 2,200 volts, 2-phase. For the more distant plants, the voltage is stepped up in transformers from 2,200 volts, 2-phase, to 11,000 volts, 3-phase. The local distributing plant consists of a subway 2,155 feet long with a horseshoe-shaped cross section 3.83 feet by 5.5 feet and of 1,031,000 duct feet of conduit composed of vitrified tile ducts. Approximately 90% of these ducts are 3½ inches in diameter and the remainder 4 inches in diameter. The conduits contain about 550,000 feet of lead sheath copper cable. Approximately one-half of this cable is 3/0, 3-conductor and insulated for operation at 11,000 volts. The remainder consists principally of 1,000,000 and 1,250,000 c. m. cable insulated for operation at 2,200 volts. On the Canadian side of the river the local distributing plant consists of one 3-phase, 2,200 volt and one 3-phase, 11,000 volt overhead circuit having an aggregate length of about ten miles.

STEP-UP TRANSFORMER PLANTS:

For long-distance transmission, the electrical power delivered by the generators is stepped up to a higher voltage in order to decrease as much as possible the transmission losses and the cost of transmission lines. This is done by means of transformers located in transformer stations near the different Power Houses. The step-up transformer plant on the American side of the river contains 20 air-blast transformers of 1,250 h. p. each, built by the General Electric Company, which change the generated current from 2200-volt, two-phase, to 22,000-volt, three-phase, and 14 oil-insulated, water-cooled transformers of 2,500 h. p. each, built by the Westinghouse Electric and Manufacturing Company, which transform the generated current into three-phase current at either 11,000 volts, or 22,000 volts, as may be required. On the Canadian side of the river, the step-up transformer plant, located on the bluff above the Power House, contains fifteen 1,675 h. p. transformers built by the General Electric Company, and six 5,850 h. p. transformers built by the Canadian Westinghouse Company, which change the generated current from 11,000 volts, three-phase, to either 22,000, 33,000, 38,500 or 57,300 volts, three-phase, by slight changes in the connections.

LONG-DISTANCE DISTRIBUTING PLANTS:

From the step-up transformer plants overhead circuits distribute the electrical power at 22,000 volts to Buffalo, the Tonawandas, Lockport, Olcott and Fort Erie. A general plan of the circuits is shown in Fig. 3 on page 11. At various central points, substations are located in which step-down transformers, converters, etc., are installed, and from which the power is again distributed in convenient form for the local customers. From the American step-up transformer station, the long-distance distributing plant to Buffalo

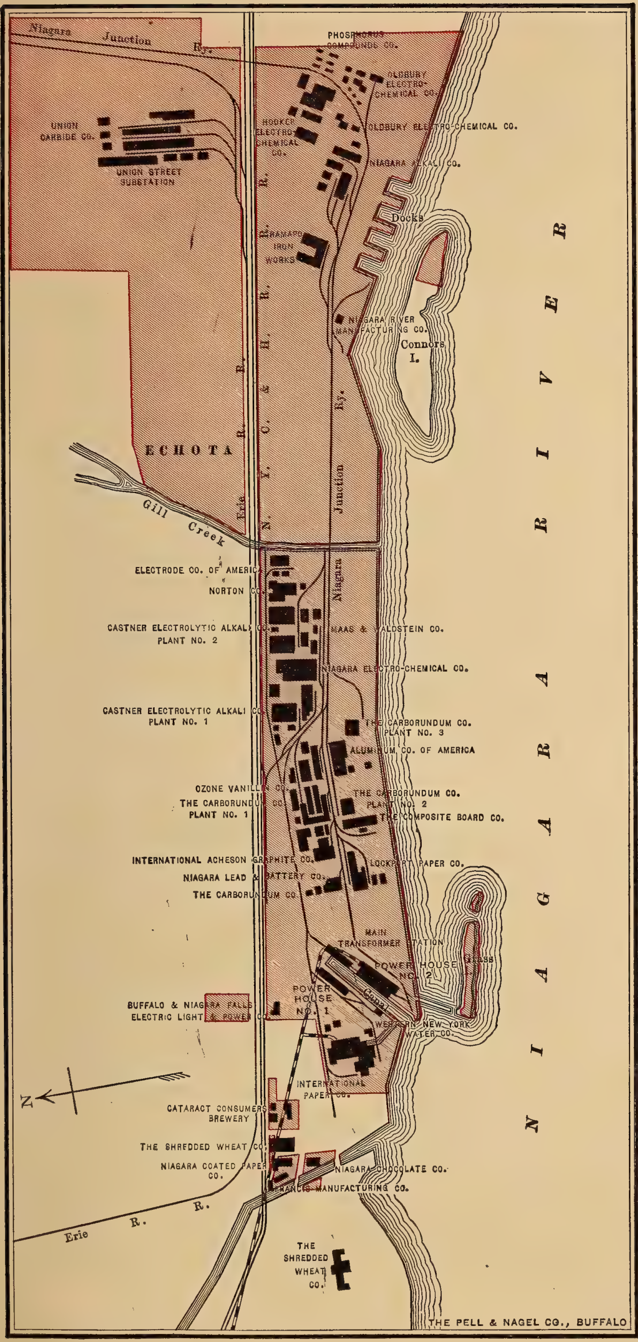


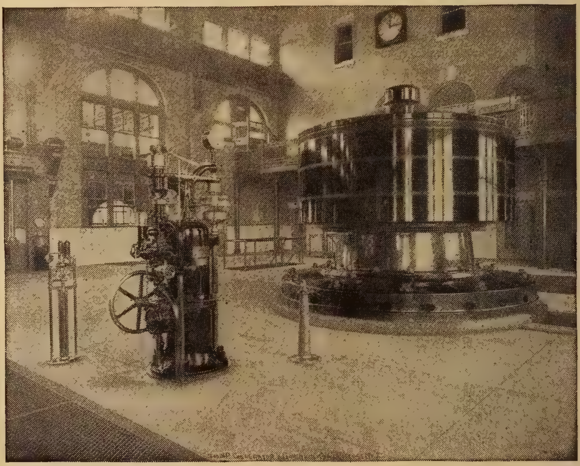
Fig. 4 Map of Local Distributing Plant and Lands. The Niagara Falls Power Company

comprises two separate and distinct pole lines, 19.5 and 22.5 miles long, carrying four tri-phase transmission circuits. Two circuits consist of copper cable 350,000 circular mils in cross section, approximately $\frac{7}{10}$ inch in diameter; the other two circuits are of aluminum cable having a cross section of 500,000 circular mils and a diameter of approximately $\frac{8}{10}$ inch. On the Canadian side of the river there are two pole lines carrying four tri-phase 22,000-volt transmission circuits. The poles on this line are steel of special construction designed by the Power Company's engineers. The conductors are aluminum cables 500,000 circular mils in section and having 37 strands. The transmission lines on both sides of the river can be interconnected at the Buffalo end making almost impossible any serious interruption to the Buffalo service.

FACTORY SITES:

The Niagara Falls Power Company owns about two miles of continuous river frontage on the Niagara River and about 1,100 acres of land in the City of Niagara Falls and in the Town of Niagara, all of which is reserved for manufacturing purposes. A map of part of this land along the river front adjacent to the two American Power Houses is shown in Fig. 4 on page 13. Here are already located some thirty industries consuming over 106,000 h. p. A terminal railway runs through the lands belonging to the Power Company and directly connects each factory by means of sidings with all the great east and west trunk lines centering at Buffalo. Connection can also be made by water with the Great Lakes and with the Erie Canal.

On the Canadian side of the river, the Canadian Niagara Power Company owns similar manufacturing sites conveniently located near the Grand Trunk and Michigan



5500 h. p. Generator and Governor, Power House No. 2.

Central Railways. The two allied companies afford, therefore, exceptional facilities for manufacturing purposes in either the United States or Canada, which are especially advantageous to any company wishing to carry on manufacturing work in both countries under one management.

MISCELLANEOUS DATES AND FACTS:

October 4, 1890,	Ground broken for tunnel.
August 26, 1895,	Power first delivered commercially. This power was used by The Pittsburg Reduction Company in the reduction of aluminum ore.
November 15, 1896,	Niagara power first delivered commercially in Buffalo.
February 12, 1900,	Ground broken for tunnel extension to Wheelpit No. 2.
May 24, 1900,	Generating Unit No. 10 in service, marking the completion of Power Plant No. 1
May 23, 1901,	Ground broken for tunnel for Power House of Canadian Niagara Power Company.
October 31, 1902,	Unit No. 11 (first machine in Power House No. 2) in commercial service.
March 16, 1904,	Unit No. 21 in Power House No. 2 in commercial service, marking completion of Power Plant No. 2.
January 2, 1905,	Two machines in operation at Power House of Canadian Niagara Power Company.
December 5, 1910.	Unit No. 6 in Power House of Canadian Niagara Power Company in commercial operation.

The maximum output of the three Power Houses up to date is 163,700 h. p., of which 57,000 h. p. is delivered in Buffalo, the Tonawandas, Lockport, Bridgeburg and Fort Erie, and 106,700 h. p. is used locally by industries on the Power Company's lands. The total output of the three plants for the year ended February 28th, 1913, was 868,285,380 kilowatt-hours. To produce this output by steam would require the consumption of 1,800,000 tons of coal, or 5000 tons daily.

ORGANIZATION

The Niagara Falls Power Company

President,
EDWARD A. WICKES, New York City.

Vice President and General Manager,
PHILIP P. BARTON, Niagara Falls, N. Y.

Secretary,
F. L. LOVELACE, Niagara Falls, N. Y.

Treasurer and Assistant Secretary,
W. PAXTON LITTLE, New York City

Canadian Niagara Power Company

President,
WALLACE NESBITT, Toronto, Ontario.

Vice-President and Secretary,
A. MONRO GRIER, Toronto, Ontario.

General Manager,
PHILIP P. BARTON, Niagara Falls, N. Y.

Treasurer,
W. PAXTON LITTLE, New York City.

STAFF

Superintendent of Operation,
L. E. IMLAY, Niagara Falls, N. Y.

Assistant Superintendent, The Niagara Falls Power Co.
T. N. HICKS, Niagara Falls, N. Y.

Assistant Superintendent, Canadian Niagara Power Co.
ALEX. D. ROBB, Niagara Falls, Ont.

Mechanical Engineer,
C. C. EGBERT, Niagara Falls, N. Y.

Engineering Assistant,
R. V. ROSE, Niagara Falls, N. Y.

Purchasing Agent,
C. M. SAXE, Niagara Falls, N. Y.

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